COLORADO RIVER RISK STUDY

SUMMARY DISCUSSION FOR THE WEST SLOPE JOINT BASIN ROUNDTABLE MEETING

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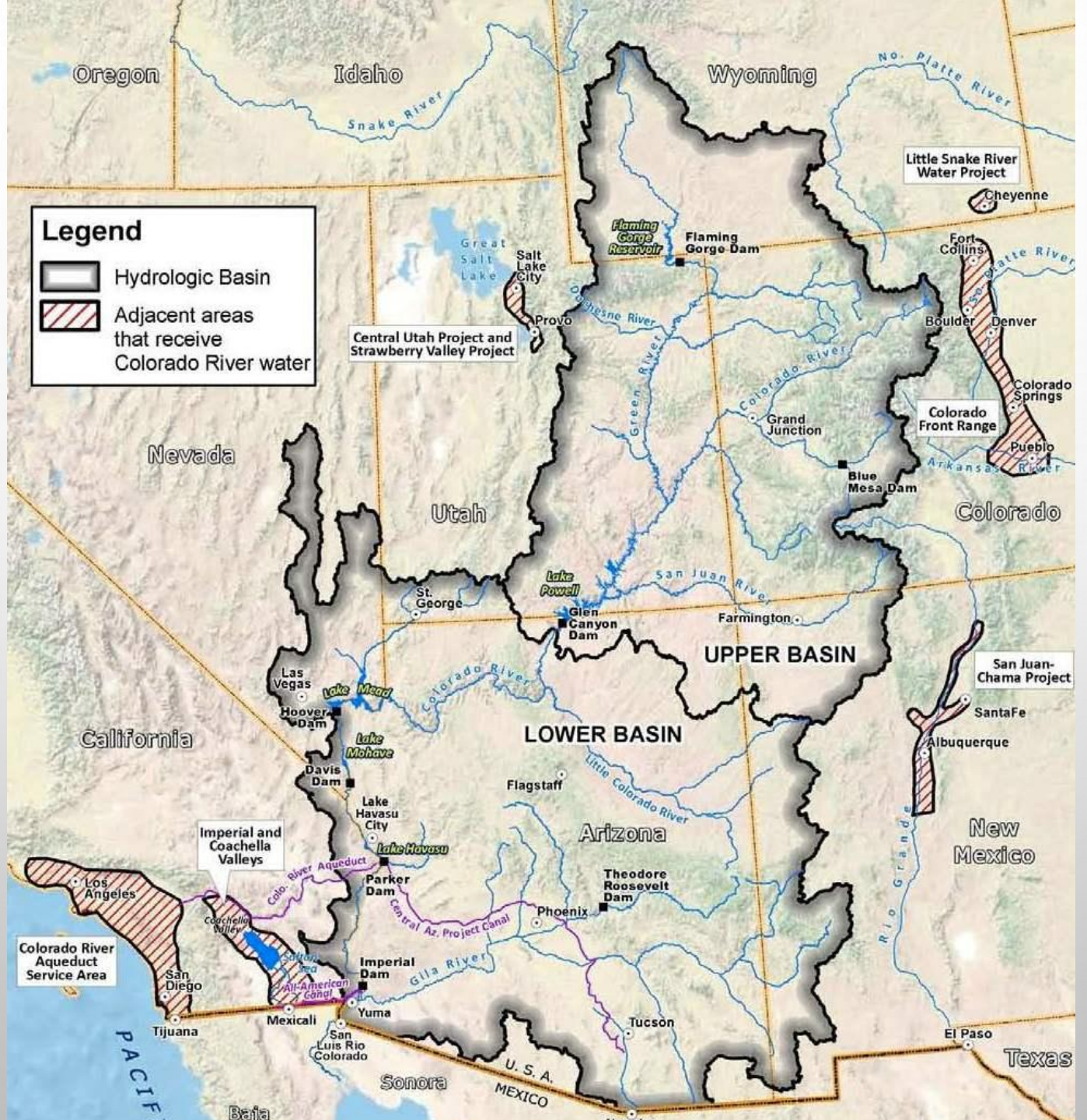

Legend
Hydrologic Basin
Adjacent areas that receive Colorado River water
Oregon
Idaho
Wyoming
Nevada
Utah
Colorado
California
Arizona
New Mexico
Texas
Snake River
No. Platte River
Little Snake River Water Project
Cheyenne
Flaming Gorge Reservoir
Flaming Gorge Dam
Great Salt Lake
Salt Lake City
Provo
Central Utah Project and Strawberry Valley Project
Duchesne River
Green River
Colorado River
Fort Collins
Boulder
Denver
Colorado Springs
Colorado Front Range
Pueblo
Arkansas River
Grand Junction
Blue Mesa Dam
Lake Powell
Glen Canyon Dam
San Juan River
Farmington
St. George
UPPER BASIN
LOWER BASIN
San Juan-Chama Project
SantaFe
Albuquerque
Las Vegas
Lake Mead
Hoover Dam
Lake Mohave
Davis Dam
Flagstaff
Little Colorado River
Lake Havasu City
Lake Havasu
Imperial and Coachella Valleys
Colo. River Aqueduct
Parker Dam
Theodore Roosevelt Dam
Phoenix
Central Az. Project Canal
Los Angeles
Coachella Valley
Salton Sea
All-American Canal
Imperial Dam
Gila River
Rio Grande
Colorado River Aqueduct Service Area
San Diego
Mexicali
Yuma
Tijuana
San Luis Rio Colorado
Tucson
El Paso
Sonora
U. S. A.
MEXICO
PACIF
Baja

BACKGROUND AND CATALYST FOR RISK STUDY

- 2014: In light of the ongoing drought, and at the urging of Secretary Jewell, Upper Colorado River Commission and Lower Basin States begin coordinated, but independent development of Drought Contingency Plans (DCP).

- Dec 2014 Joint West Slope BRT Meeting. Participants express an interest in understanding more about the risks of ongoing drought, the DCPs, and what a demand management program might look like for Colorado River water users.

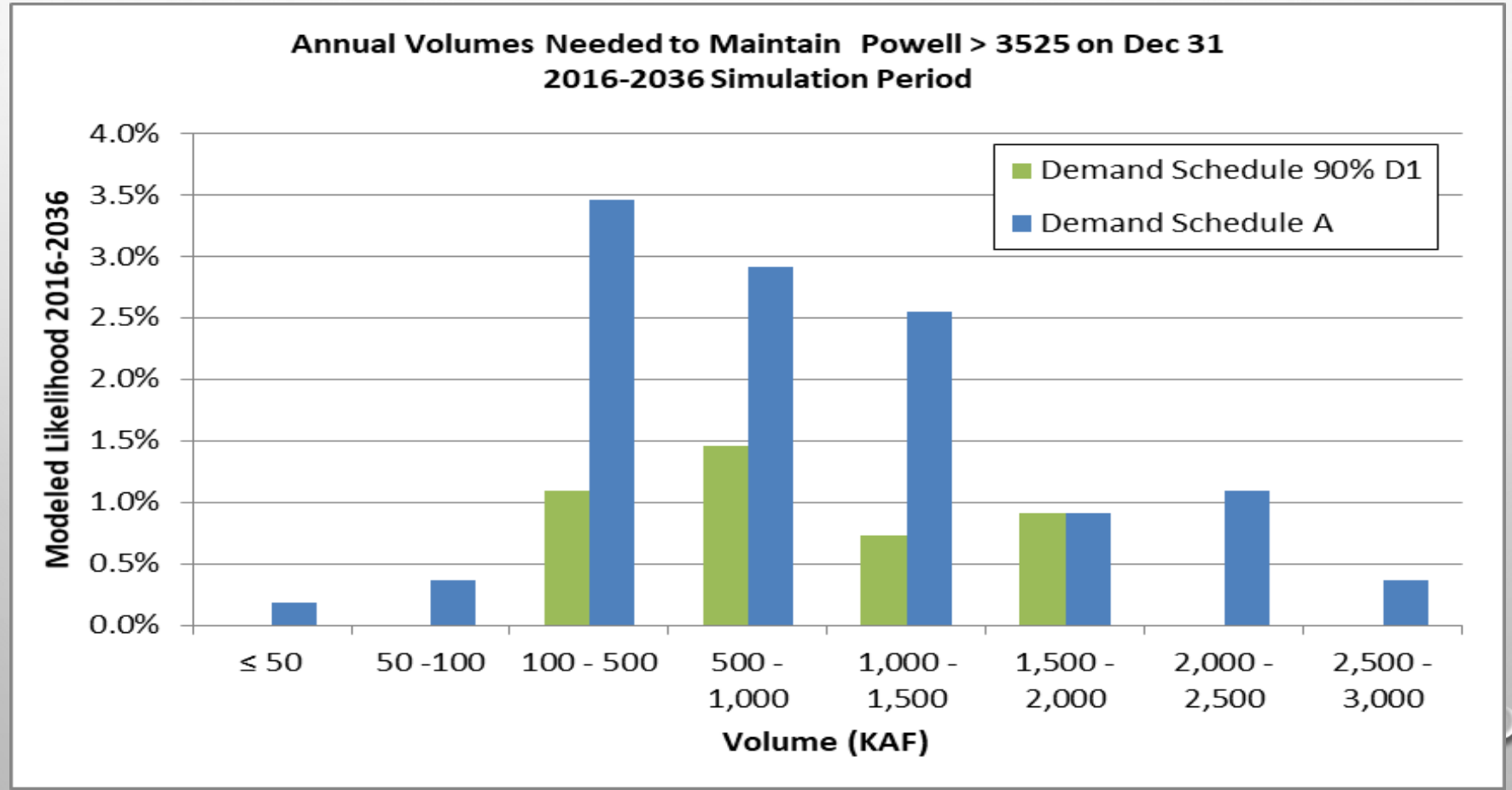
- Colorado's Water Plan: Take actions that will minimize risk of compact curtailment actions (pt. 4 of Seven Point Framework)

COLORADO RIVER RISK STUDY – PHASE I

- Upper Basin Drought Contingency Plan identifies 3525' as a critical pool elevation at Lake Powell which triggers action
  - Why? Below 3525', Powell could quickly drop to levels where hydropower production is lost, and could have implications for meeting upper basin obligations under the 2007 Interim Guidelines and 1922 Compact.
- Questions addressed in Phase I:
  - What are magnitude and duration of Powell "shortages" below elevation 3525'?
  - How much of these shortages can be met by contributions from Drought Operations of CRSP reservoirs? (A: up to about 2 MAF)
  - How much consumptive use reduction (demand management) would be needed by Upper Basin states - AFTER use of stored CRSP water - in order to maintain Powell pool elevations?
- Utilize Reclamation's CRSS model to address these "Big River" questions

HOW MUCH WATER MIGHT BE NEEDED TO KEEP POWELL ABOVE CRITICAL ELEVATIONS?

- Amount of additional water required after drought operation of CRSP reservoirs
- Given a particular hydrology, higher consumptive use in the UB leads to higher likelihood of deficit at Powell



PHASE I CONCLUSIONS

- Hydrology and Demands (current and future) are key drivers to risk. For a given hydrology, the higher the consumptive use in the Upper Basin the higher the risk to existing users.
- Drought Contingency Planning is essential, CRSP reservoir drought operations reduces the risk, as does a robust Lower Basin plan, but in more severe droughts (e.g., 1988-1993 & 2001-2005), demand management may also be needed
- Some of the deficit volumes we are seeing in the model are very large and reactive demand management to offset those is probably not feasible.
- One possible solution: Demand Management combined with a Water Bank:
  - Could limit the annual impact to consumptive uses by spreading conservation over a number of years
  - Would provide greater control over conserved water - use only if/when necessary ***

PHASE II: STATEMOD WORK
"PROOF OF CONCEPT" MODELING

"Evaluate the utility of using StateMod in addressing questions related to voluntary demand management. Understand capabilities and limitations"

1. Uniform reduction in consumptive use across all direct flow rights
    a. 5%, 10%, 15% reductions; variations by hydrology and sub-basin.
2. What is state line yield with and without shepherding?
3. Can we represent water banking mechanisms in the model?
    a. What are model requirements for a bank, including triggers and operating rules?
4. Coupled StateMod / CRSS
    a. Why? Each modeling tool has strengths and weaknesses
    b. "linked" simulations: ex: Powell elevations (CRSS) drive water bank operations, while demand management yields from StateMod dictate availability of banked water .

ALL YEARS (1988-2012)

- Reduce CU (demand management) on all direct flow rights
- Efficiency is percent of conserved water reaching state line (non-shepherded).

	5%			10%			15%		
	Outflow (AF)	DM (AF)	% yield	Outflow (AF)	DM (AF)	% yield	Outflow (AF)	DM (AF)	% yield
Yampa	8,774	10,134	87%	17,930	20,269	88%	27,189	30,403	89%
White	2,917	2,982	98%	5,894	5,963	99%	8,940	8,945	100%
Upper Colorado	42,873	52,673	81%	87,250	105,346	83%	133,701	158,019	85%
Gunnison	20,631	28,655	72%	42,056	57,310	73%	64,256	85,964	75%
San Juan & Dolores	14,476	23,439	62%	31,387	46,879	67%	49,449	70,318	70%
TOTAL	89,671	117,883		184,517	235,766		283,535	353,650	

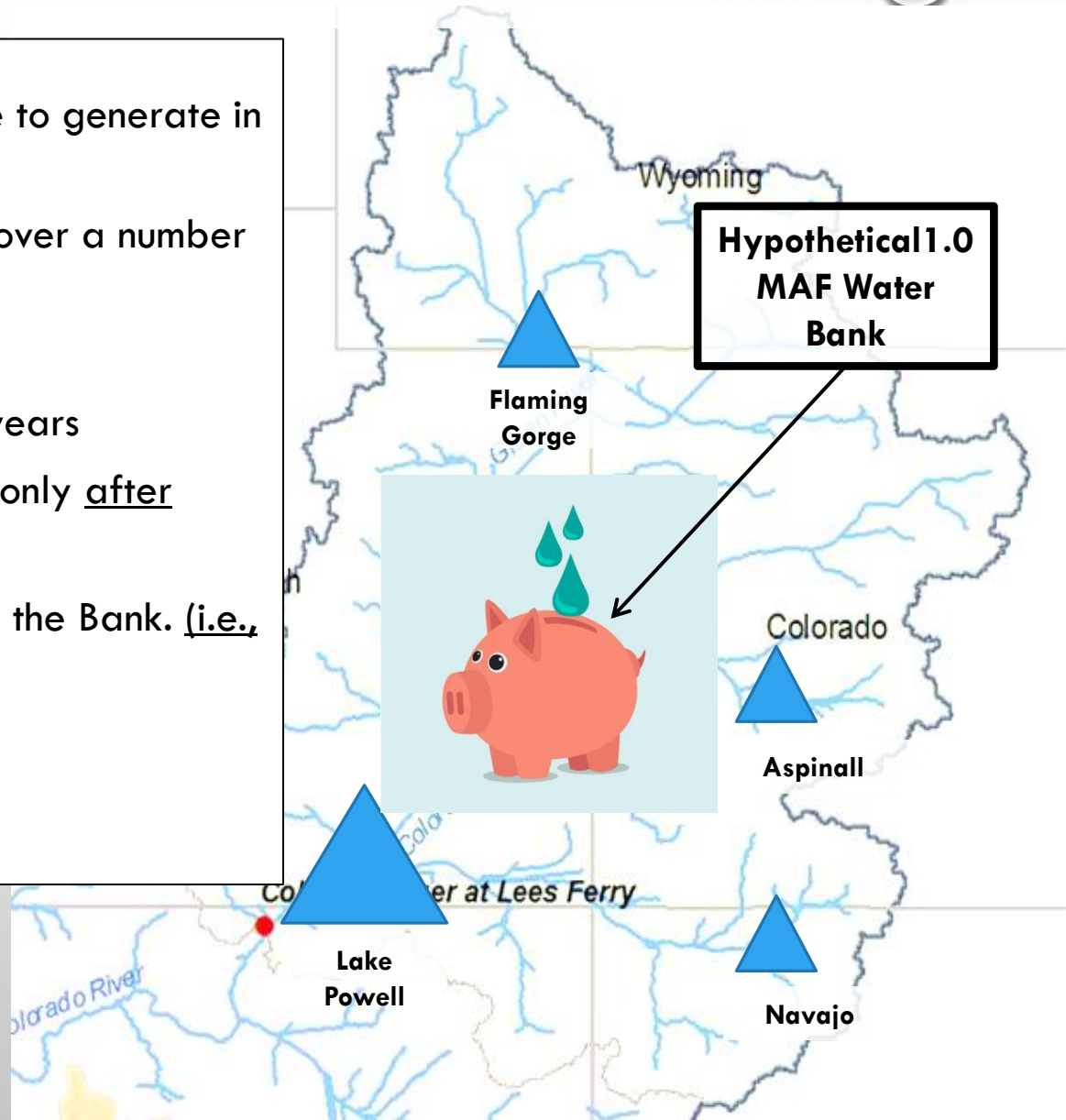
DRY YEARS

- Reduce CU (demand management) on all direct flow rights
- Efficiency is percent of saved water reaching state line (non-shepherded).

	5%			10%			15%		
	Outflow (AF)	DM (AF)	% yield	Outflow (AF)	DM (AF)	% yield	Outflow (AF)	DM (AF)	% yield
Yampa	7,101	9,809	72%	14,852	19,617	76%	22,678	29,426	77%
White	2,720	2,916	93%	5,545	5,833	95%	8,434	8,749	96%
Upper Colorado	21,110	51,685	41%	40,213	103,370	39%	67,529	155,055	44%
Gunnison	8,427	26,345	32%	21,877	52,689	42%	37,658	79,034	48%
San Juan & Dolores	9,541	20,706	46%	19,744	41,412	48%	28,870	62,118	46%
TOTAL	48,899	111,461		102,231	222,921		165,168	334,382	

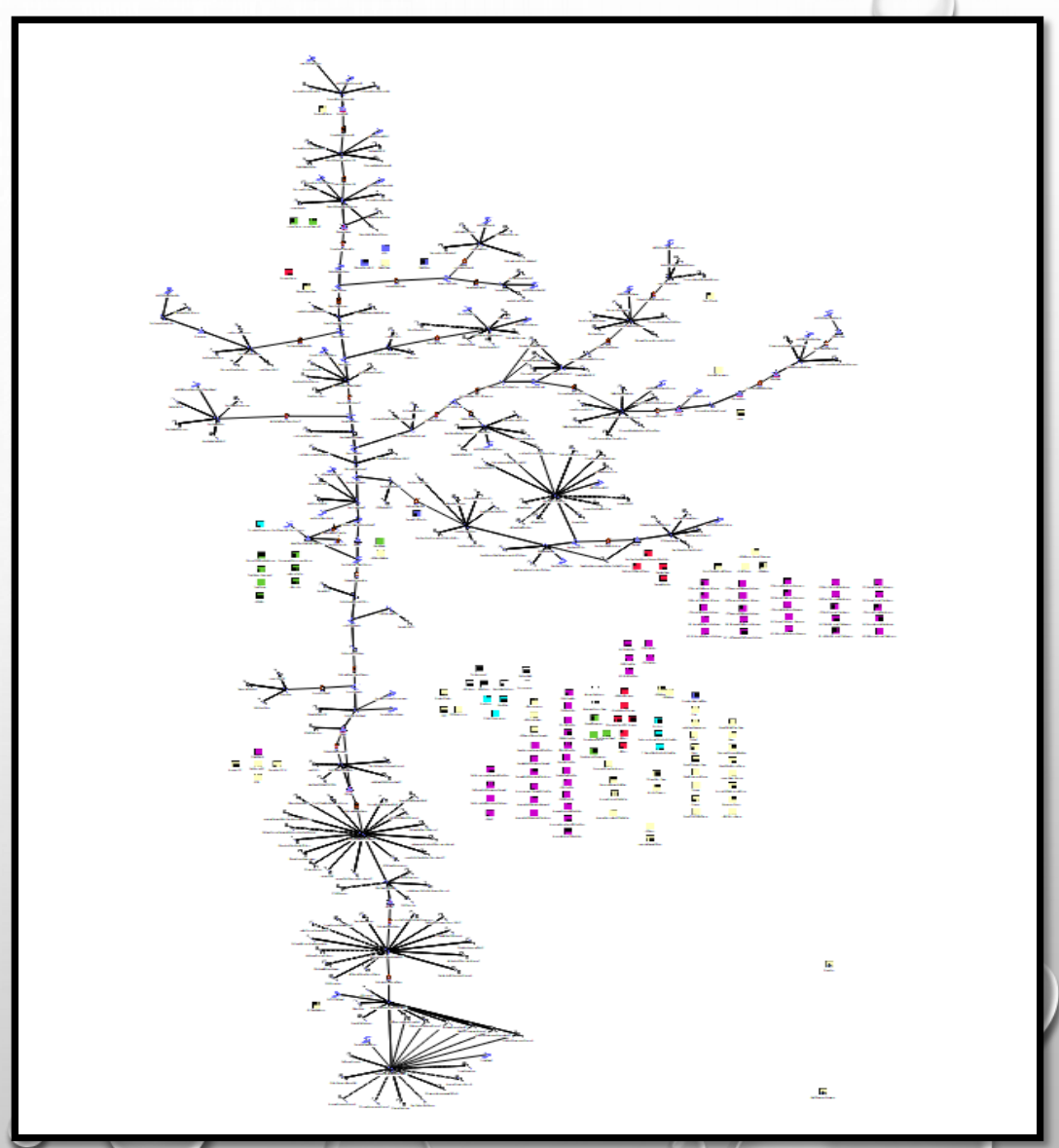
WATER BANK MODELING CONCEPT

- Recap: Demand Management volumes required are likely too large to generate in a single year
- Need to store conserved Demand Management water proactively, over a number of years, for use if/when necessary
- Model Assumption: Create a 1.0 MAF capacity bank:
  - Fill with conserved Demand Management water over several years
  - Bank releases water to support Lake Powell elevation (3525), only <u>after</u> Drought Operations of upstream CRSP Reservoirs
  - Banked water should not be *system water* unless released from the Bank. <u>(i.e., not subject to equalization and tiering operations</u>)



CRSS / STATEMOD COUPLING

- Colorado River Simulation System (CRSS)
  - Good: representation of “Big River” operations;
  - Bad: does not simulate water right administration in Colorado
- StateMod
  - Good: Simulates priority administration of water, additional yield from demand management activities;
  - Bad: model is Colorado-specific; No “knowledge” of Powell/Mead or other “big river” conditions
- Implementation: Utilize StateMod for development of demand management yields, use CRSS to manage the resulting bank and usage of water at Powell



RISK STUDY PHASES I & II SUMMARY

- Regarding Risk: Hydrology, Consumptive Use, and Future Demand growth matter. We can't control hydrology, but higher the consumptive use in the Upper Basin coupled with a given hydrology will increase the likelihood of critical events at Lake Powell.
- Phase I Take-away:
  - CRSP reservoir drought operations reduces the risk, but in more severe droughts, demand management could be necessary to maintain critical elevations. (some of these deficit volumes are quite large)
- Phase II Take-aways:
  - StateMod is capable of simulating detailed questions related to demand management, shepherding, and variability of water yield across basins and within different years (e.g., wet/avg/dry)
  - StateMod is "limited" by its focus on in-state water right administration (this is not a bad thing)
  - By coupling StateMod with CRSS, we have a tool capable of addressing the administrative questions of demand management within Colorado together with the external driver of Lake Powell operations.
  - Demand Management / Water Bank proof of concept outcomes:
    - Limit the annual volumetric impact of demand management by spreading conservation over many years
    - Provide control over conserved water (a "must have" condition to prevent unintended releases from Powell)
    - Implementation time horizon is potentially quite long – decades, not years.

WHAT'S NEXT?

Let's ask Mr. Mueller…

END

WHERE DO WE GO FROM HERE?

- If DM/Water Bank is pursued, what are the goals?
  - Volume/timing/location(s)?
  - Economics: who pays and when?
  - Hydropower vs. Compact (loss of HP would likely occur well before Compact issue)
- If DM/Water Bank is NOT pursued, what are other options?
  - Implication of not moving forward with a bank?
- Can we quantify the economic cost of action or inaction?
- What are ground rules? State-wide targets? Sub-basin specific?
- Integration with other UB States?
- Legal issues: Shepherding, Water Bank accounting/contracting, etc.

RISK SENSITIVITY TO HYDROLOGY